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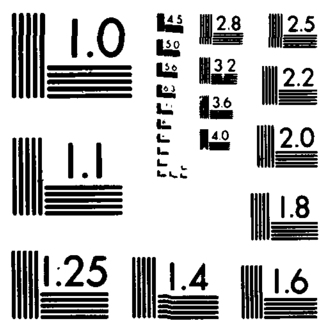

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FOREIGN TECHNOLOGY DIVISION

AIR FORCE SYSTEMS COMMAND

THE SEA WIND OF GDANSK (DANZIG)

by

H. Koschmieder

FOREIGN TECHNOLOGY DIVISION

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THE SEA WIND OF GDANSK (DANZIG)

H. Koschmieder (Gdansk).

(With 6 figures.)

In order to capture the phenomenon of the sea wind in the most complete form possible, in the four years from 1932 to 1935 a ground network was used which is shown in Fig. 1. The coast line is drawn in, in the NE lies the Gulf of Danzig, in the SW, Gdansk. In 1932 the three stations: airfield, Broesen-Bad and Glettkau-Bad were put into operation and all were equipped with thermohygrographs and gust recorders. This triangular arrangement has certain advantages as will be shown later.

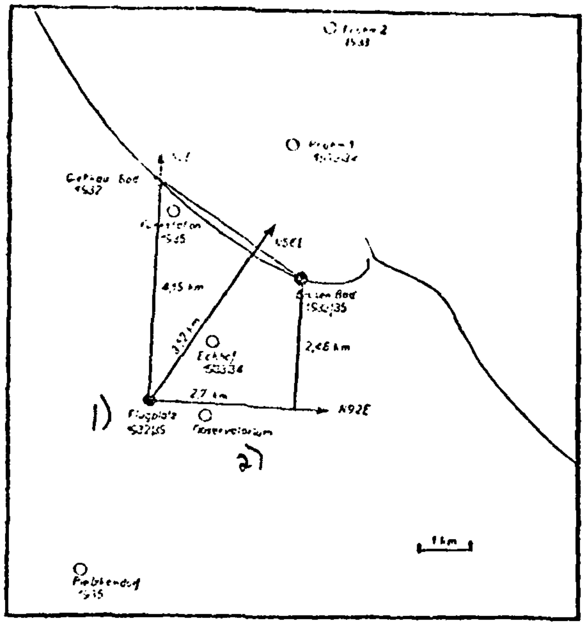


Fig. 1. KEY: 1. airfield; 2. observatory.

The longest side of the triangle is a little over 4 km. In 1933 and 1934 the stations: airfield, Eckhof, and Broesen-Bad were used, again with the same equipment. The three stations lie on almost a straight line. This line was extended seaward through two barges so that there were five stations on a straight line. In addition in 1933 and 1934 aerological airplane ascents were made on selected days; usually three, but sometimes five ascents, in order to measure the vertical temperature stratification outside and inside of the sea wind. Simultaneously there were pilot balloon launchings. The pilot

balloons were launched primarily at the Glettkau radio station and located with theodolite and range finders. In 1935 a triangular arrangement of the airfield, Broesen-Bad and the Glettkau radio station, was once again used whereby the thermohygrographs were equipped with day drums in order to achieve greater accuracy in time. In 1935 there were additional pilot balloon launches simultaneously at the airfield and at the Glettkau radio station which were once again carried out with theodolite and range finders. Occassionally it was possible to record the conditions precisely when the sea wind had already set in in Glettkau but not yet at the airfield.

The material obtained in this manner is extraordinarily extensive. The mechanical evaluation is generally finished. So far the year 1932 has been processed in detail and we shall report about it here.

I. The first question is: Is there, in fact, a sea wind in Gdansk which is independent of the isobaric distribution?*

[FOOTNOTE: *This manner of expression will have to suffice here. In the complete publication exact definitions of concepts and characteristics will be given. END FOOTNOTE.]

That the answer to this question is yes can be confirmed from a number of individual cases. As von Ficker says in his investigations of the foehn, the method of individual cases does not enjoy any great popularity, because it makes repetitions unavoidable but it is nevertheless the only method which has really persuasive force. Here in addition it is a necessary supplement to the excellent statistical investigation of the Gdansk sea wind by M. Kaiser in 1907. In the following examples the weather situation was investigated and it was determined whether or not a sea wind was actually involved. We cannot go into details here.

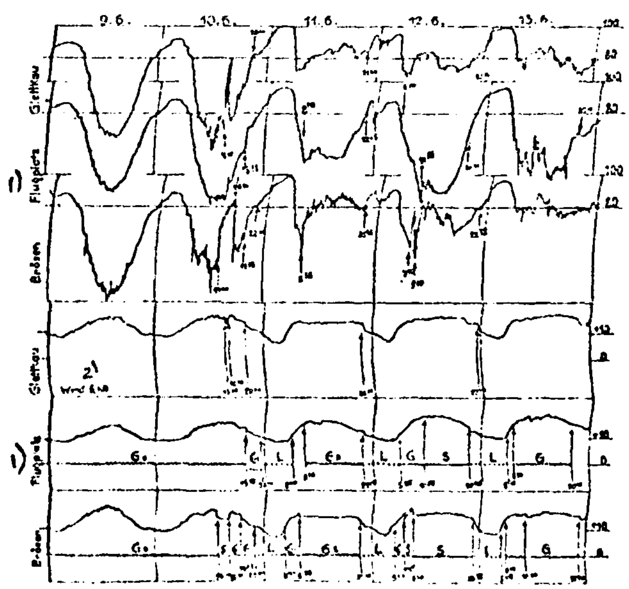


Fig. 2. KEY: 1. airfield; 2. no wind.

The remark must suffice that to the extent that nothing else is mentioned the sea wind cannot be considered as a gradient wind of the general meteorological situation.

Fig. 2 shows the temperature and humidity distribution for 9 to 13 June 1932. On 9 June a land wind WSW-W, Beaufort 4 to 3, prevails. The inland station at the airfield and the two coastal stations at Broesen and Glettkau show the normal temperature and humidity distribution. On 10 June the land wind continues until about 1400. At 1400 in Broesen the sea wind sets in and at 1530 in Glettkau. At 1610 the sea wind ends in Glettkau and at 1650 in Broesen; the sea wind out of the NNE does not reach the airfield. At a distance of about 3.5 km, airfield - coast, nearly opposing air movements prevail. The gradient wind later again breaks through to Broesen and Glettkau agaist the sea wind; after 2000 the wind drops at all stations, the weak air movement comes out of the SSW and one could interpret it as a land wind. Here, as in all other cases, the movement of air from the land to the sea is extremely weak at night so that one can hardly speak of wind, but rather of a swelling of the cooling air masses toward the sea. On 11 June we have a gradient wind from the sea and one recognizes that with the beginning of this sea gradient wind the

temperature rise has ended but a noticeable temperature range does not appear. In the night from 11 to 12 June one again finds the weak land wind, the wind velocity remains for the most part under the threshold of stimulation of the gust recorder but the weather vanes at both stations are turned to the SW. On 12 June at about 0500 in the morning the gradient wind from the SE sets in again and one finds the first sea wind in Broesen at 0745 and the second sea wind at 0930. The sea wind continues throughout the day. In the night from the 12th to the 13th the wind direction shifts back to the SW which is made evident in the temperature recording by a deep drop. Toward 0600 in the morning the gradient wind out of the NE sets in and, as on the 11th at the coast stations, produces an almost straight temperature curve.

The sequence of these days contains very nearly all types of temperature patterns which can appear on the coast:

on the 9th the normal continental type with land gradient wind,

on the 10th, especially in Broesen, the temperature drop from the sea wind,

on the 11th and 13th an almost rectilinear temperature curve with a sea gradient wind,

in the night from the 12th to the 13th a particularly pronounced sharp temperature drop with a night land wind.

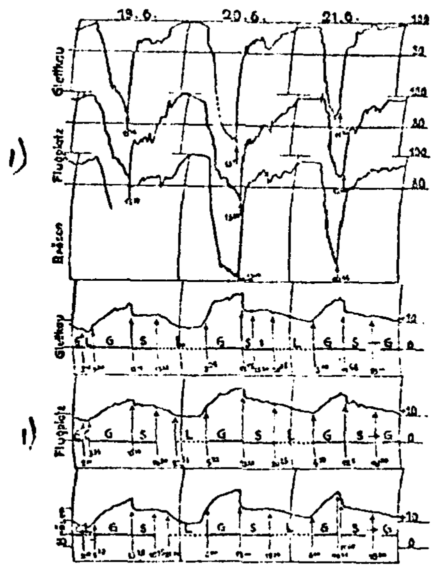


Fig. 3a. KEY: 1. airfield.

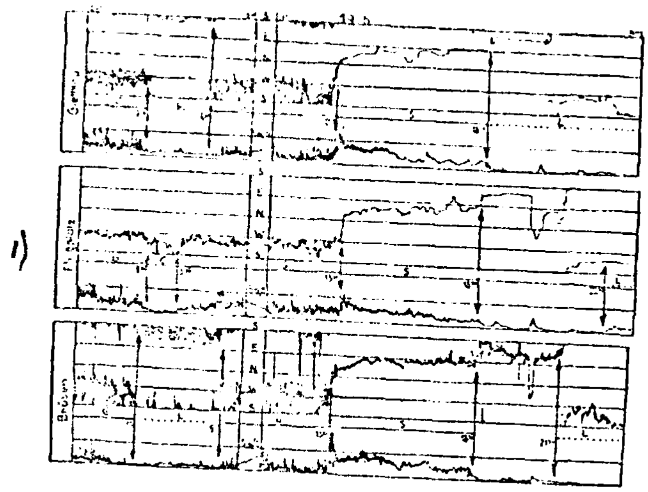


Fig. 3b. KEY: 1. airfield.

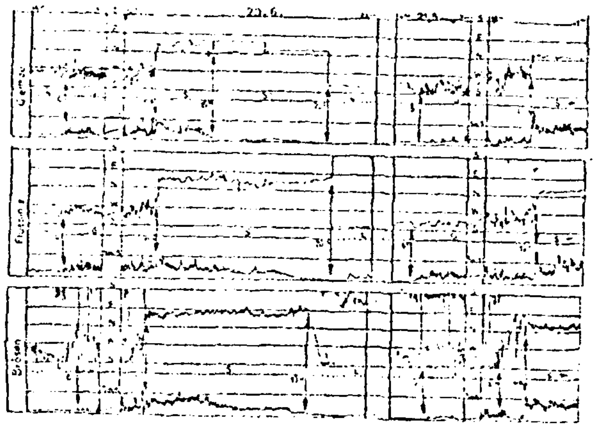
1)


Fig. 3c. KEY: 1. airfield.

Fig. 3* shows the three days from 19 to 21 June in which the sea wind is particularly clearly expressed.

[FOOTNOTE: *In order to save space the complete wind recordings are not reproduced, but only the excerpts which contain the changes of wind direction (or any ambiguities). Of course the complete recordings give a much more direct impression than these excerpts. END FOOTNOTE.]

Its onset on all three days is characterized by marked drops in temperature, which exceed 5°, and by correspondingly large increases in humidity. The onset on this day is also particularly clear in the wind recordings and the onset occurs here with regular gusts which reach 8-10 m/s. And finally the days are also characterized by the expressed gradient winds from the WSW, Beaufort 3 to 2, so that here there can be no doubt about the nature of the sea wind. Noteworthy on all three days is the regular sequence

G -> S -> L, G -> S -> L, G -> S -> G,

G = gradient wind, S = sea wind, L = land wind.

Fig. 4 shows particularly good wind sequences from 20 July:

in Broesen G -> S -> G -> L,

in Glettkau G -> S -> G -> S -> G -> L,

and likewise at the airfield, although the temperature pattern there is not so pronounced as in Glettkau.

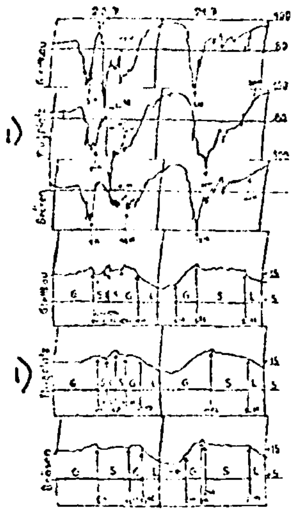


Abb. 4 a

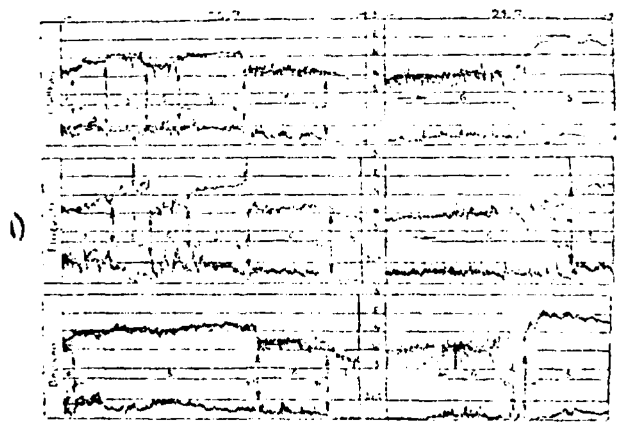


Abb. 4 b

Fig. 4a, b. KEY: 1. airfield.

These multiple changes in the wind can only be explained by the battle between the gradient wind and the sea wind, a glorious experiment of nature and a clear proof for the existence of the sea wind.

II. It is now important to determine the relationship of the three stations to each other with respect to the time of the onset of the sea wind. One is in the position, because of the triangular arrangement of the stations to calculate the front direction and the displacement velocity of the front. Fig. 5 shows the three stations: the airfield, Broesen, and Glettkau, the position of the front which arises between the cool sea air and the warm land air, and also the times t_0, t_1, t_2 at which the front passes the three stations.

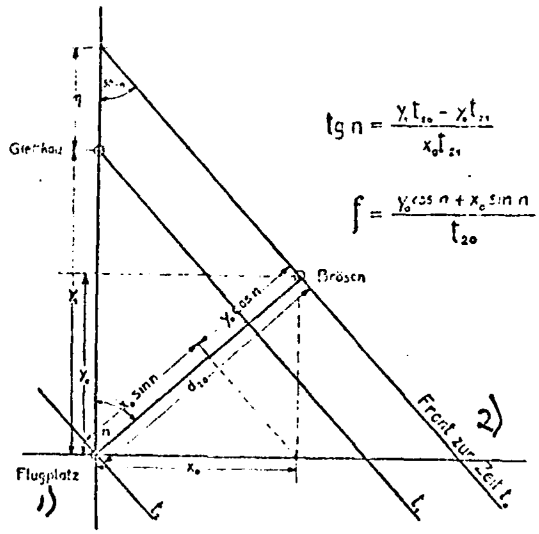


Fig. 5. KEY: 1. airfield; 2. front at time t_0.

Assuming that the front moves parallel to itself and with constant velocity then one obtains for the front normal the expression given in the figure above, and for the front velocity the expression below it. Therein x_0, y_0, x_1, y_1 are the coordinates of Broesen and Glettkau with respect to the airfield, t_{20} and t_{21} are the time differences which are formed from the onset of the sea wind at the airfield, Glettkau and Broesen. If one uses these formulas, which can be of advantage for many investigations, to evaluate the observations of the year 1932 then one finds an unexpected result.

Table 1 shows the utilizable cases. In the first column stands the date, in the second the direction of the front normal, in the third the front velocity in m/s, in the fourth the observed sea wind according to direction and velocity, the latter once again in m/s, in the fifth the angle between the wind direction and the front normal and in the sixth the quotient of the front velocity divided by the component of the horizontal wind velocity which lies normal to the front. The seventh column gives the gradient wind with the velocity according to Beaufort.

1) Datum	2) Richtung n der Normale	3) Frontgeschw.	4) Seewind w: 5) Richtung	6) Geschw.	7) Winkel zwischen w u. n	/ w_n	8) Gradientwind
	Grad	m/sec	Grad	m/sec	Grad		Beaufort
19.6.1932	N 5 W	3.1	N 26 E	5.0	+ 31	0.73	WSW 2
20.6.1932	N 82 E	2.0	N 49 E	3.6	33	0.67	WSW 2
21.6.1932	N 32 E	3.7	N 26 E	5.2	- 6	0.71	W 2
1.8.1932	N 8 W	2.3	N 15 E	4.7	+ 23	0.53	SSW 3
2.8.1932	N 16 E	2.1	N 7 W	3.1	- 23	0.73	WSW 3
14.8.1932	N 18 W	0.2	N 83 E	2.9	+ 101	—	SE 1
15.8.1932	N 1 W	0.5	N 91 E	2.9	+ 95	—	SE 2
17.9.1932	N 59 E	2.4	N 57 E	2.7	- 2	0.89	WSW 3

Table 1. KEY: 1. date; 2. direction n of the normal, deg.; 3. front velocity, m/s; 4. sea wind w; 5. direction, deg.; 6. velocity, m/s; 7. angle between w and n, deg.; 8. gradient wind, Beaufort. This is

not the case, however, but the wind velocity component taken in the direction of the front normal is 11 to 47°/₀ greater than the front velocity.

Care must be taken so that as the wind velocity one does not use the gust velocity, which often appears with the onset of the sea wind and which is considerbly higher than the wind velocity shortly after the onset. Rather as the wind velocity we use an average value of the three stations: the airfield, Glettkau, Broesen, whereby for each of the three stations the average value during the time t_{20} or t_{21} was already used.

The year 1935, in which the time accuracy is greater than in 1932, confirms these results. In addition in 1935 recording contact anemometers were used in order to determine the average wind velocities more accurately. Using them the same picture results: with a sea wind which is perpendicular to the front the advancement velocity of the sea wind is noticeably smaller than the wind velocity of the sea wind.

This observed fact can only be explained by the fact that the sea air which is breaking in does not simply move inland horizontally like a rigid body. Because then the front velocity would have to be equal to the sea wind velocity. It is necessary, instead, to assume

that the intruding sea air rises in the front side of the squall head. Then in fact the wind velocity can be any amount greater than the propagation velocity of the sea wind. Thus the intruding sea air does not execute a simple translational movement like a rigid body, which would correspond to the flow line schematic in Fig. 6a, but rather the air particles of the sea air shift continuously against each other as a result of the forced vertical movement on the front, possibly corresponding to the flow line diagram in Fig. 6b.*

[FOOTNOTE: *The series of intermediate forms between the limiting cases a and b will be given in the complete publication. END FOOTNOTE.]

This kinematically possible picture is also dynamically clear: because in it lies the idea that the sea air on its upper surface is partially carried seaward by the shearing force of the land gradient wind. The upper boundary of the sea air flowing inland is thus to be sought there where the pressure drop caused by the cold air or its gradient force is exactly equal to the shearing force which is exerted on the sea air by the air masses of the gradient wind flowing toward the sea.

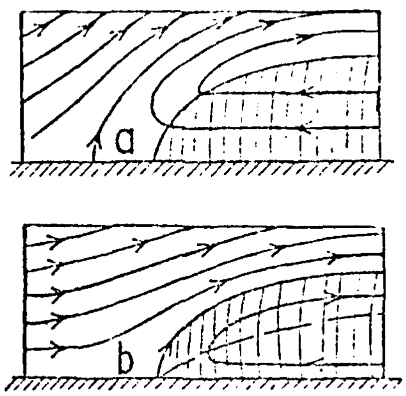


Fig. 6a, b.

III. Why the sea wind appears on the Gdansk coast with preferred frequency and velocity, why exactly with a land gradient wind, why so much stronger than the almost disappearing "land wind," what effect the coriolis force has on the course of the movement and how the energetics of the sea wind look have already been clarified to a great extent.*

[FOOTNOTE: *Postscript during correction: In the meantime it has been

possible to combine the details into a compact theory of the sea wind. END FOOTNOTE.]

These questions along with further examples of the sea wind will be treated in Part 8 of the "Research Works of the State Observatory of Gdansk."